Technical Series 00-122

STUDY OF THE NOISE GENERATED BY HEAT PUMPS IN RESIDENTIAL AREAS

Introduction

The number of domestic heat pumps installed has increased substantially recently due, on one hand, to rising energy costs (oil, gas and above all, electricity) and, on the other, to aggressive marketing. Heat pumps are usually located outside the house where connection to the heating and ventilation systems is easiest. In some circumstances, a noise disturbance is generated in the neighbourhood. In fact, all heat pumps, regardless of whether or not they have an integrated compressor, are noisy. They all have a powerful fan which directs outside air to ensure that all the coils are cooled. In addition to this noise, there is also the noise of the compressor itself and, the noise of the refrigerant gas circulating. Municipalities in Quebec are receiving an increasing number of complaints, especially during the summer, about this type of residential utility. Those without any municipal noise bylaws are thinking about adopting such bylaws to counter this type of disturbance.

The research project, subsidized by CMHC, on the noise generated by heat pumps in residential areas, thus had several objectives: first of all, to analyze the noise pollution mode of the most commonly used heat pumps in residential areas; subsequently, to study the possibility of a simple noise reduction device to confine the noise produced by this type of residential utility; to verify to what extent this device had to be adapted to each of the various machines; and finally, to ensure that the selected device would not reduce the thermal capacities of the pumps, both in air-conditioning and heating modes.

The first stage of the study took place between May and August 1990. It verified, *in situ*, the noise produced by the major heat pump brands in the Québec City area. Most of the single-family residential districts in this area were systematically visited. One hundred and twenty-five heat pumps were thus identified either because they were visible, or could be heard from the street. After having analyzed the distribution by brand of the 125 heat pumps in the sampling, TRANE was the most frequent with 38 units, followed by CARRIER, YORK and LENNOX, with 28, 18 and 10 units respectively.

Sampling and On-site Measurements

To trace a realistic picture of the general noise characteristics of the heat pumps identified, an initial measurement of the sound pressure level was taken at a distance of one metre from each unit. Thus 80 reference files were opened with pumps generating noise levels from 52.5 to 70.6 dB(A). For this first batch of files, the distribution by brand of the 125 heat pumps identified was respected as far as possible. Moreover, in this sampling of

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80 heat pumps, 20 from amongst the noisiest, were studied in greater depth. The detailed noise measurements dealt essentially with the determination of the sound power of each heat pump and with two reference 1/3 octave spectrum bands to characterize the noise of the fan, the first one in front of the pumps and the second on top.

The results of the global noise measurements in dB(A), taken at a distance of one metre from each unit serve to confirm that most heat pumps can be considered as noisy (with the exception of the top-of-the-line and newer models). In addition to this first observation, the data for the 80 heat pumps for which measurements were taken show that certain brands and models are noisier than others. In addition, it was observed that the location of the heat pump in relation to the house is often one of the reasons for its impact on the neighbourhood. Thus certain pumps that we ranked "middle of the pack" in our sampling were considered by neighbours as being very noisy due to their less than optimum location which aggravated the noise situation.

The *in situ* measurements thus made it possible to attain the main goal which had been set for the research project, i.e., to broaden our knowledge of noise pollution modes and of the noise generated by exterior heat pumps in their utilitarian context, i.e., residential districts.

Sound Attenuation Feasibility Study

To respect the statistical compilation recorded on site, a TRANE heat pump was chosen for a detailed muffler feasibility study. Not only did this brand seem to be the most popular but, in addition, it was still possible to find an older model of the same brand which was relatively noisier than the most recent series of products. Ideally, it would have been desirable to have a used pump but the fact is that no installer could provide us with one. The model chosen was a 2-ton pump which is common and relatively noisy. As for the two other pumps chosen for further study, these were units which had been in service for several years, a YORK pump and a LENNOX pump.

The TRANE pump was installed in the new measurement chambers in the "Laboratoire d'acoustique de l'Université Laval". The heat pump model was installed in an anechoic chamber and the air circulation device, for research purposes, was installed in the large adjoining reverberent chamber. This experimental exercise made it possible to take both noise and thermal measurements at the same time to attain the main objective of the research project, i.e., the development of a device which does not affect either the thermal or the air flow requirements of the heat pump. The air handler was set up in a vertical position; two perpendicular intake and exhaust ducts were used to recirculate the air in the opposite corners of the measurement chamber.

The exterior unit of the heat pump had two main sources of noise: the compressor itself, installed at the bottom of the pump, in the middle of the coil, and the fan, placed at the top of the pump and also in the middle of the coil. The noise attenuation device finally proposed for this type of pump had to meet four objectives: first of all, to control the noise produced as near as possible to the source, with a shield attached to the exterior envelope of the heat pump; then, using a simple muffler, to reduce the level and modify the directivity of the main source of noise represented by the fan at the top of the pump; reduce the lateral radiation of noise from the four air-intake sides of the heat pump (since once the fan noise is controlled, it is the noise radiation which is the culprit in residential areas); lastly, to allow for a good air flow in the heat pump by ensuring, if possible, the separation of the air intake and the air exhaust.

For practical reasons, the muffler placed at the fan exhaust was not modified; its length, moreover, was the only element which could have been changed (to a certain extent, to the detriment of the air flow). That is why the possible modifications in the noise reduction device focused on the four air-intake sides of the heat pump. This was done in accordance with three different intervention stages. Noise measurements determined the general sound pressure of the heat pump and analyzed the composition of the noise produced on the different sides of the pump. To take into consideration the possible directivity of various noise sources, the acoustic pressure and intensity measurements were all taken simultaneously. Nevertheless, this precaution did not make it possible to identify any particular directivity of the pump's noise pollution because of the pump's very open design. The detailed calculation of the noise pressure subsequently made it possible to assign the result of each stage in the installation of the muffler and to evaluate the global noise reduction achieved. The objective of the air flow measurements was to determine whether noise

reduction measures on heat pumps could have any influence on the thermal performance of the pump and, if necessary, to provide details on any possible changes in the pump's mechanical behaviour. These measurements dealt with the detailed determination of air speeds in the various parts of the heat pump and with the verification of temperature spreads between the intake and exhaust air flows. This latter category of measurement was also used on the "air handler" side, especially as pertains to different speeds and to the corresponding temperature differential.

A constant air flow rate, with or without the muffler, is an essential condition for the effectiveness of the devices studied. It has to be pointed out, however, that the heat pump's shield and the layout of its components already significantly obstruct air flow, in particular, the orientation, the dimensions and the nature of the intake and exhaust screens. The temperature spreads or average differential at the pump's intake and exhaust points have a direct effect on the air flow rate. Higher velocities reduce the spreads and vice versa.

To complete this detailed laboratory experiment, two other mufflers were designed and installed on relatively different pumps, i.e., a 3-ton YORK heat pump with intake screens on the four lateral sides and with exhaust air expelled by a fan on top of the pump, and a 3-ton LENNOX heat pump, with intake screens on two of the lateral sides and with exhaust on the two opposite sides. The YORK heat pump resembled to a certain extent the TRANE model which had been studied in laboratory although it had additional air intake screens on the three edges of its casing. On the other hand, the LENNOX heat pump was very different from the other two since it was completely closed in on the top with the air circulating diagonally (through the pump's casing).

General Conclusion

It was concluded that exterior residential heat pumps are a major source of continuous noise and are certainly a source of environmental disruption in low- and mid-density residential areas. The noise levels produced vary depending on the power of the pumps, their technology, when they were manufactured, their degree of wear and tear, and how they are placed around the residences.

Avoid placing the pumps near neighbouring windows or near reflecting surfaces such as a wall or hard-packed soil which can aggravate the noise situation. Nevertheless, regardless of the situation, it is always possible to build a noise attenuation device around heat pumps. This solution is preferable to the construction of a curtain wall, since the screen wall would obstruct the circulation of air around the machine.

An effective muffling device must be installed as close as possible to the casing of the heat pump and include appropriate mufflers for the pump's air intake and exhaust points, in addition to an insulated central envelope. Unfortunately, one device cannot be designed to fit all pumps; it has to be designed and built in accordance with the dimensions and characteristics of each particular heat pump model. If necessary, this device can be supplemented by coating the closest wall with an absorbent material to control sound reflection. For example, the acoustic results obtained from the various mufflers tested were weighted to reflect the pumps' respective intake and exhaust surfaces (to obtain a global noise reduction figure): the muffler installed on the YORK heat pump was the most effective with noise reduction in excess of 16 dB(A), whereas the two other models achieved a very respectable global noise reduction capacity in excess of 11 dB(A).

A well designed muffler will not affect the thermal performance of heat pumps. It is possible that thermal performance of the pumps may be enhanced due to better air flow separation at the intake and exhaust points. For a robust model in thick galvanized steel, the cost of a noise muffler may vary between $400 and $600. This should not be considered exorbitant when this device can ensure the tranquillity of your neighbourhood.

Project Manager: Jacques Rousseau

Research Report: *Study of the Noise Generated by Heat Pumps in Residential Areas*

Research Consultant: Gabriel Migneron

A full report on this project is available from the Canadian Housing Information Centre at the address below.

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Ottawa, ON K1A 0P7

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